EM Feature

Multiple Pathway Health Risk Assessment of a Municipal Waste Resource Recovery Facility in Maryland

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Following a 1986 decision by Montgomery County in Maryland to construct a municipal waste resource recovery facility near the town of Dickerson, local residents expressed concern regarding the potential health risks associated with the proposed facility. In response, the county conducted a multiple pathway health risk assessment for a generic facility in 1989. The Dickerson facility was then constructed and began operation in 1995. In 2003, the county conducted an update to the 1989 study. This article presents results from both the 1989 study and the 2003 update.

In 1989, Montgomery County in Maryland retained Roy F. Weston to conduct a multiple pathway health risk assessment for a proposed solid waste resource recovery facility (RRF) to be constructed near Dickerson, MD.[1] The health risk assessment was based on a review of the literature on engineering (i.e., stack design) and emissions data for existing RRFs in the United States, Canada, and Europe, and also incorporated one year's worth of meteorological data collected from the Potomac Electric Power Co. generating station, located one-half mile northwest of the proposed site. The health risk assessment focused on pollutants for which there were no established air quality standards, but for which there was a body of evidence that indicated potential effects on human health. It used established procedures that were accepted by the U.S. Environmental Protection Agency (EPA) and many state agencies at that time.

Following the 1989 health risk assessment, Montgomery County contracted Covanta Energy (formerly Ogden Martin Systems) of New Jersey to design, build, and operate the solid waste RRF near Dickerson. The RRF was constructed and became operational in May 1995. The *Facilities Master Plan for the Solid Waste Operations in the Dickerson Area*,[2] which was prepared for the county in consultation with the Dickerson Facilities Master Plan Oversight Group (a group consisting of interested citizens living in the area) in 1997, recommended that the air quality modeling and health risk assessment be updated periodically. After six years of operation, and again at the request of the surrounding community, the county decided to update the 1989 study. In 1999, ENSR International was retained to conduct an update to the air quality modeling/deposition analysis and health risk assessment. There were two main reasons for updating the original study: (1) actual engineering and stack emissions data were now available for the Montgomery County RRF, and (2) EPA had published several updates to multipathway health risk assessment procedures since 1989. Specifically, the *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities*, published in 1998,[3] and an *Errata*, published 1999,[4] providing a more comprehensive methodology for evaluating the potential risk to human health associated with combustion facility emissions. The updated health risk assessment considered as-built stack engineering parameters, measured stack emissions rates, onsite meteorological data, and updated air modeling and risk assessment methods (including toxicity values and exposure assumptions) currently recommended by EPA.

Nineteen compounds of potential concern (COPCs), including polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzo-furans (PCDFs), polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs), and several other carcinogenic and noncarcinogenic metals, were selected for evaluation in the health risk assessment update. The results of the air dispersion and deposition modeling were used to evaluate potential human exposures from direct (i.e., inhalation of air) and indirect (i.e., ingestion of soil, vegetables, dairy products, beef products, chicken, eggs, or fish) pathways. Both children and adults were evaluated for potential exposures to facility-related COPCs from all potential exposure pathways and the results were compared with the 1989 health risk assessment.

DESCRIPTION OF THE SITE AND FACILITY

The Montgomery County RRF is located approximately 2 miles southwest of Dickerson on land adjacent to the coal-fired electric power generating station owned by Potomac Electric Power Co. (see Figure 1). The area surrounding the facility is largely rural. The majority of the area within a 15-mile radius of the RRF is used for a mix of residential and agricultural purposes. A

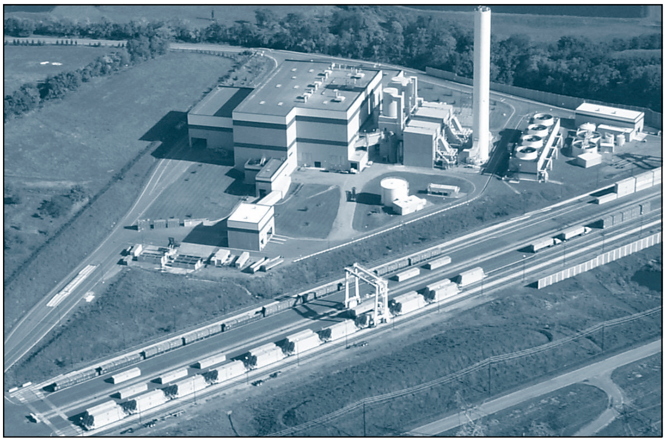

Figure 1. Montgomery County solid waste RRF.

few scattered residences are located within 2 miles of the facility, three townships (Beallsville, Barnesville, and Dickerson) are located within 5 miles of the facility, and several recreational areas are located within 10 miles of the facility. These include the Chesapeake and Ohio Canal National Park, the Dickerson Regional Park, the Monocacy Natural Area, and Sugarloaf Mountain. The Potomac River, located to the west of the facility, is also used for recreational activities. In addition, there are several farm ponds within 3 miles of the facility where recreational fishing takes place.

The facility is made up of three units. Each unit is designed to combust up to 600 tons of solid waste per day and generates approximately 20 MW of electricity. Each unit has a separate flue and is equipped with state-of-the-art air pollution control (APC) equipment. The APC equipment consists of a dry scrubber and fabric filter baghouse for controlling acid gases, particulates, and organics; direct lime injection into the furnace for additional acid gas control; ammonia injection at the top of the furnace for nitrogen oxide control; and activated carbon injection at the scrubber inlet for mercury control. In addition, the combustion residue is treated with dolomitic lime to minimize the leaching of metals from residue.

HEALTH RISK ASSESSMENT UPDATE

The methodology for a health risk assessment includes selecting chemical compounds that are of potential concern from a public health perspective, conducting air dispersion/deposition modeling of these compounds to determine ground-level mass concentrations and conducting exposure and toxicity assessments, characterizing the health risk from each compound, and estimating the total health risk to individuals exposed to these compounds. This process is described below.

Selection of Compounds of Potential Concern

Based on a review of the 1989 health risk assessment and recent stack emissions measurements, 19 COPCs were selected for evaluation in the 2003 update, including PCDDs, PCDFs, PCBs, and PAHs. The update focused on compounds that are found to be a significant fraction of emissions released from the facility and have the potential to pose health risks. All COPC emissions data were compiled from 18 stack tests performed at the RRF between 1995 and the present. The measured emissions rates are estimated to be representative of normal operating conditions for the facility. These data are presented in Table 1.

Air Dispersion and Deposition Modeling

The Industrial Source Complex Short-Term, Version 3 (ISCST3), model was used for air dispersion and deposition modeling in accordance with EPA guidance.[3] The health risk assessment calculations require dry and wet deposition for both particle and vapor components. Therefore, model iterations were performed using the ISCST3 options for wet and dry deposition of particles and wet deposition of vapor. Onsite meteorological data taken from a 10-m tower were also used in the application of ISCST3. The results were to evaluate potential human exposure from direct and indirect pathways.

Exposure Assessment

Based on characteristic activities in Montgomery County and the most recent EPA guidance for health risk assessments for waste combustion facilities, the potential human exposures evaluated in the update were inhalation of particulates and vapor in air; incidental ingestion of soil; ingestion of vegetables from

Table 1. COPCs and emissions rates under normal operating conditions.

COPC	Emission Rate (lb/hr)[a]	Emission Rate (g/sec)[a]
Inorganics/Metals		
Antimony	2.41E-04	3.04E-05
Arsenic	2.40E-04	3.02E-05
Beryllium	4.04E-05	5.10E-06
Cadmium	1.58E-04	1.99E-05
Chromium (Total)	3.56E-04	4.49E-05
Chromium (VI)	1.73E-04	2.17E-05
Cobalt	1.71E-04	2.15E-05
Copper	4.18E-04	5.27E-05
Lead	9.18E-04	1.16E-04
Manganese	6.16E-04	7.76E-05
Mercury	5.54E-03	6.98E-04
2Nickel	6.64E-04	8.37E-05
Selenium	2.90E-04	3.66E-05
Zinc	4.39E-03	5.53E-04
Organics		
Dioxins/Furans—TEQ	1.14E-08	1.43E-09
PCBs	4.20E-04	5.29E-05
Carcinogenic PAH (as BAP-TE)	1.80E-06	2.27E-07
Total PAH	8.41E-04	1.06E-04
Formaldehyde	5.22E-03	6.58E-04

[a]Emission rate is for a single unit.

a backyard garden; consumption of milk, beef, pork, chicken, and eggs from area farms; and ingestion of fish from the Potomac River. In addition, recreational fishing from several local ponds was also evaluated. Both children and adults were evaluated for exposure to facility-related COPCs via all potential exposure pathways. By evaluating all potential pathways, a complete picture of health risks was developed for the surrounding community.

ENSR evaluated two maximally exposed individual (MEI) scenarios, which are updates to Scenarios A and B used in the 1989 study.[1] Under updated Scenario A, an MEI local resident is evaluated at the location of the maximum air concentration and maximum dry deposition of the RRF exhaust plume. Under updated Scenario B, an MEI local resident is evaluated at the location of maximum total deposition (dry + wet) and secondary maximum air concentration. In addition, several other potential scenarios were evaluated, including the evaluation of residents near three area ponds (identified as Ponds 1, 2, and 3 in the 1989 study). Residents near the three ponds were assumed to be exposed to COPCs in facility emissions through inhalation exposures; consumption of products (e.g., above- and below-ground vegetables) grown in a backyard garden; consumption of fish caught from the ponds; and incidental ingestion of soil.

Toxicity Assessment

In addition to identifying relevant potential exposure scenarios, a toxicity assessment was conducted to determine the relationship between the magnitude of exposure (dose) for each COPC, and the occurrence of specific health effects for a receptor (response). A variety of EPA sources[3] were consulted to obtain the latest carcinogenic and noncarcinogenic dose–res ponse values for COPCs.

Risk Characterization

The results of the exposure and toxicity assessments were combined in risk calculation equations to estimate the potential risk to human health. This step is referred to as "risk characterization." The potential risk to human health is a calculation of the likelihood of adverse carcinogenic or noncarcinogenic health effects occurring in humans under the conditions described in the above scenarios.

The predicted potential for adverse carcinogenic health effects is referred to as the excess lifetime cancer risk (ELCR). The ELCR can be compared to EPA's target risk limit of 10 chances in 1 million for combustion facilities.[3] The predicted potential for adverse noncarcinogenic health effects is referred to as the hazard index (HI), and is a ratio of the predicted

Table 2. Summary of predicted cancer risk.

	Scenario A[a]		Scenario B[b]		Subsistence Farming Scenario[c]		Subsistence Fishing Scenario[d]		Pond Fishing Scenario[e]	
COPC	**Adult**	**Child**	**Adult**	**Child**	**Adult**	**Child**	**Adult**	**Child**	**Adult**	**Child**
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor 1254	2.50E-09	8.20E-10	3.14E-09	1.21E-09	2.83E-09	6.90E-10	2.45E-08	3.43E-09	6.19E-09	1.87E-09
Arsenic	2.93E-09	1.23E-09	4.69E-09	2.58E-09	2.83E-09	6.53E-10	2.59E-09	1.10E-09	1.34E-09	5.82E-10
Total B(a)P-TE	5.01E-10	1.75E-10	6.53E-10	2.74E-10	2.05E-09	5.43E-10	5.69E-10	8.21E-11	9.62E-11	3.26E-11
Beryllium	1.35E-09	1.18E-09	1.71E-08	2.15E-08	2.12E-09	6.91E-10	7.48E-10	4.66E-10	1.15E-09	1.12E-09
Cadmium	6.83E-09	2.36E-09	1.11E-07	3.85E-08	1.09E-08	2.87E-09	7.54E-09	1.57E-09	7.33E-09	2.46E-09
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium, hexavalent	4.49E-08	1.64E-08	8.95E-08	4.23E-08	1.78E-07	4.67E-08	7.67E-09	3.07E-09	8.55E-09	3.38E-09
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Formaldehyde	1.75E-10	7.76E-11	9.22E-11	4.03E-11	7.56E-11	2.52E-11	1.75E-10	7.77E-11	7.76E-11	3.44E-11
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercuric chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	3.58E-10	1.59E-10	1.61E-10	7.16E-11	1.37E-10	4.57E-11	3.58E-10	1.59E-10	1.46E-10	6.50E-11
Total PAH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDD-TEQ	1.27E-07	3.08E-08	1.79E-07	8.11E-08	5.0833E-07	8.1078E-08	2.5128E-07	3.7366E-08	3.96E-08	1.45E-08
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	1.86E-07	5.32E-08	4.05E-07	1.88E-07	7.07E-07	1.33E-07	2.95E-07	4.73E-08	6.45E-08	2.41E-08

Notes: [a]MEI local resident evaluated at the location of the maximum air concentration and maximum dry deposition; [b]MEI local resident evaluated at the location of the maximum wet deposition and secondary maximum air concentration; [c]Subsistence farmer evaluated at the nearest actual farm location predicted to be maximally impacted by facility-related emissions; [d]Subsistence fisher was assumed to consume fish from the Potomac River and reside at the location of the primary maximum air concentration; [e]Most conservative of three pond scenarios evaluating residents near the ponds exposed to facility emissions though inhalation, consumption of agricultural products in a backyard garden, consumption of fish caught in the pond, and incidental soil ingestion.

intake and the tolerable dose of a given compound. The latest EPA guidance recommends a target HI of 0.25 for hazardous waste combustion facilities.[3] For most regulatory programs, including Superfund and Resource Conservation and Recovery Act corrective action risk assessments, the target HI is 1. The lower target HI suggested for hazardous waste combustion risk assessments is intended to account for the potential contribution of other sources of hazardous constituents. Therefore, when risk characterization results for all COPCs are below or equal to EPA's acceptable cancer risk limit and noncarcinogenic target HI, no further analysis is presumed to be necessary.

ASSESSMENT RESULTS

The predicted carcinogenic and noncarcinogenic health risks for the various scenarios mentioned above are presented in Tables 2 and 3, respectively, and are discussed below.

Potential Carcinogenic Risk

As can be seen in Table 2, the total ELCR for the worst case MEI scenario (i.e., Scenario B adult resident) is predicted to be 0.4 chances in 1 million. In the 1989 study, the total ELCR for the worst case MEI scenario was predicted to be 0.9 chances in 1 million. Thus, the ELCR in the updated assessment is less than half that predicted in the 1989 assessment. This is due to the use of actual stack emissions data collected since the RRF became operational in 1995. The estimated emissions rates used in the 1989 health risk assessment were higher than the actual measured emissions. Even if the Scenario B adult resident were assumed to ingest fish caught from one of the local ponds, the predicted ELCR would be no higher than 0.43 chances in 1 million. This is also well below EPA's target risk limit for combustion facilities of 10 chances in 1 million.

In all cases summarized in Table 2, potential indirect exposure to PCDD and PCDF emissions is evaluated as total tetra-chloro dibenzo dioxins–toxic equivalents (TCDD–TEQs), which represents the greatest portion of predicted carcinogenic health risk. The total ELCR is estimated to be 0.7 chances in 1 million for an adult subsistence farmer, 0.3 chances in 1 million for an adult subsistence fisherman, and 0.06 chances in 1 million for an adult recreational pond fisherman. All predicted ELCR in the 2003 update are well below EPA's target risk limit for combustion facilities of 10 chances in 1 million. This indicates a very low likelihood that potential carcinogenic health effects would occur under the range of exposure scenarios evaluated in this health risk assessment.

Potential Noncancer Hazard

As can be seen in Table 3, a noncarcinogenic HI of 0.029 is predicted for the worst case MEI scenario (i.e., Scenario B child resident). In the 1989 health risk assessment, the total HI for the worst case MEI scenario was 0.03. Although more potential exposure pathways were evaluated in the 2003 update, the predicted HI for the Scenario B child resident was essentially equal to that predicted in the 1989 assessment.

Because the actual COPC emissions from the facility are lower than the emissions estimated in the 1989 study, use of actual emissions data in the updated assessment would lead one to expect that the predicted HI would be lower than originally predicted in the1989 study. However, substantial changes in the science underlying the prediction of exposure to mercury through the ingestion of fish accounts for more than 90% of the predicted HI for the Scenario B child resident evaluated in the updated assessment. By comparison, in the 1989 assessment, Scenario B child resident was not evaluated for potential exposure to COPC in fish. Incidental ingestion of and dermal contact with mercury in soil was estimated to account for 99% of the total HI predicted in the 1989 study. The dermal soil pathway is not recommended in EPA's latest guidance. Potential exposure to mercury through all pathways other than consumption of fish (i.e., ingestion of soil, ingestion of backyard produce, and inhalation of vapors and particles) results in a predicted HI of 0.002 for the Scenario B child resident. This is nearly a factor of 10 lower than the 1989 HI predicted for potential exposure of the Scenario B child resident to mercury in soil alone and is primarily due to the use of actual emissions rate data collected since the facility became operational in 1995.

In addition to updates of the Scenario A and B MEI receptors, potential subsistence farmers, subsistence fishermen, and local pond fishermen were evaluated in the updated assessment. As can be seen in Table 3, an HI of 0.002 is predicted for a child subsistence farmer, an HI of 0.38 is predicted for an adult subsistence fisherman, and an HI of 1.03 is predicted for a child consuming fish from a local pond. These results are generally within or below the range of target HI identified by EPA for hazardous waste combustion facilities (0.25) and general risk assessments (1).

The results of the updated noncarcinogenic risk assessment indicate that no adverse noncarcinogenic health effects are expected under the range of exposure scenarios evaluated. Even if the Scenario B child resident were assumed to ingest fish caught from one of the local ponds, the predicted HI would be no higher than 1.02. This is approximately equal to EPA's target HI of 1 for general risk assessments. In all cases, indirect

Table 3. Summary of noncarcinogenic hazard index.

COPC	Scenario A[a] Adult	Scenario A[a] Child	Scenario B[b] Adult	Scenario B[b] Child	Subsistence Farming Scenario[c] Adult	Subsistence Farming Scenario[c] Child	Subsistence Fishing Scenario[d] Adult	Subsistence Fishing Scenario[d] Child	Pond Fishing Scenario[e] Adult	Pond Fishing Scenario[e] Child
Antimony	4.34E-06	8.41E-06	3.73E-05	8.68E-05	7.34E-06	1.11E-05	2.99E-06	4.55E-06	3.15E-06	6.34E-06
Aroclor 1254	1.46E-04	2.39E-04	1.83E-04	3.52E-04	1.50E-04	2.01E-04	1.43E-03	1.00E-03	3.62E-04	5.46E-04
Arsenic	4.42E-06	8.00E-06	1.96E-05	5.68E-05	8.02E-06	1.01E-05	2.65E-06	4.61E-06	2.54E-06	5.34E-06
Total B(a)P-TE	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	2.21E-07	1.13E-06	3.45E-06	2.24E-05	2.57E-07	6.33E-07	1.13E-07	3.99E-07	2.08E-07	1.12E-06
Cadmium	2.37E-07	5.26E-07	1.06E-07	2.37E-07	6.80E-08	1.51E-07	2.37E-07	5.26E-07	9.67E-08	2.15E-07
Chromium	1.28E-08	4.59E-08	1.39E-07	7.49E-07	2.70E-08	5.39E-08	2.94E-09	1.27E-08	6.82E-09	3.56E-08
Chromium, hexavalent	8.15E-07	1.48E-06	1.69E-06	4.00E-06	2.53E-06	4.41E-06	1.09E-07	2.11E-07	1.47E-07	2.89E-07
Cobalt	1.05E-08	1.82E-08	3.74E-08	5.44E-08	1.35E-08	1.99E-08	6.53E-09	1.27E-08	7.19E-09	1.15E-08
Copper	4.17E-08	7.24E-08	1.49E-07	2.16E-07	5.36E-08	7.91E-08	2.60E-08	5.04E-08	2.86E-08	4.58E-08
Formaldehyde	4.53E-08	1.01E-07	2.39E-08	5.22E-08	1.48E-08	3.26E-08	4.54E-08	1.01E-07	2.01E-08	4.46E-08
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercuric chloride	4.13E-04	1.23E-03	6.08E-04	1.87E-03	9.09E-04	1.71E-03	6.29E-04	2.09E-03	3.52E-04	1.17E-03
Mercury	5.97E-07	1.33E-06	2.65E-07	5.89E-07	1.62E-07	3.59E-07	5.97E-07	1.33E-06	2.23E-07	4.95E-07
Methyl Mercury	1.83E-02	2.67E-02	1.83E-02	2.67E-02	7.45E-05	1.26E-04	3.80E-01	2.40E-01	7.10E-01	1.03E+00
Manganese	6.61E-05	1.47E-04	3.00E-05	6.64E-05	1.91E-05	4.23E-05	6.60E-05	1.47E-04	2.70E-05	6.00E-05
Nickel	4.62E-07	8.70E-07	1.63E-06	5.09E-06	1.26E-06	2.02E-06	1.99E-07	2.78E-07	1.51E-07	3.57E-07
Total PAH	1.85E-06	3.02E-06	6.25E-06	1.29E-05	1.36E-06	1.98E-06	2.60E-05	1.81E-05	1.60E-05	2.37E-05
Selenium	2.26E-06	4.60E-06	3.01E-06	5.97E-06	7.59E-06	1.55E-05	4.65E-07	4.81E-07	2.21E-07	3.60E-07
Total TCDD-TEQ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	2.10E-07	3.70E-07	2.15E-06	4.15E-06	2.16E-07	3.33E-07	1.36E-06	9.64E-07	4.26E-07	6.74E-07
Total	1.89E-02	2.83E-02	1.92E-02	2.92E-02	1.18E-03	2.13E-03	3.82E-01	2.43E-01	7.11E-01	1.03E+00

Notes: See Table 2.

exposure to mercury through consumption of fish represents the greatest portion of predicted noncarcinogenic hazard.

CONCLUSIONS

The above results indicate that the relative risk of harm to human health presented by the Montgomery County RRF, under current operating conditions, is very low. In fact, the health risks predicted in the 2003 assessment update are lower than or consistent with the health risks predicted in the 1989 study. The results indicate a very low chance (i.e., less than 1 chance in 1 million) for occurrence of potential carcinogenic health effects, and that no adverse noncarcinogenic health effects are expected as a result of exposure to facility-related emissions. The health risk estimates in the updated study indicate that the Montgomery County RRF does not pose unacceptable risks to the surrounding community.

It is suggested that the county periodically review (i.e., once every 10 years) the accumulated stack emissions data to determine any significant changes in the emissions of PCDDs, PCDFs, and trace metals addressed in this study. In addition, the county should keep abreast of any updates to EPA's guidance for conducting health risk assessments. If significant changes occur either in the stack emissions of organics and metals addressed in this study or EPA's protocol documents, an update to this study is recommended.

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